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ACTIVITY OF THE INSTITUTE OF PURE AND APPLIED MECHANICS OF THE ACADEMY OF SCIENCES OF THE USSR IN NOVOSIBIRSK IN THE AREA OF GAS DYNAMICS OF COMBUSTION

by

S. Wojcicki

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ACTIVITY OF THE INSTITUTE OF PURE AND APPLIED MECHANICS OF THE ACADEMY OF SCIENCES OF THE USSR IN NOVOSIBIRSK IN THE AREA OF GAS DYNAMICS OF COMBUSTION

FROM "Review of News Items and Publications" S. Wojcicki

Annual reports of the research work of the Institute of Pure and Applied Mechanics of the Academy of Sciences of the USSR in Novosybirsk have been published starting from 1972. Considerable part of that work is devoted to problems of gas dynamics of combustion. Some of the works, particulary those performed in the course of the last two years, concern hypersonic aircraft engines for the propulsion of spacecraft at velocities corresponding to Mach numbers of 4 to 15.

In recent years the Institute of Pure and Applied Mechanics of the Academy of Sciences USSR in Novosybirsk has begun to publish yearly reports of its activities. To be more specific, these reports have the following titles: "Aerodynamic Research" (1972 and 1973, each containing about 130 pages), "Gas Dynamics and Physical Kinetics" (1974, 200 pages), and "Problems of Gas Dynamics" (1975, 330 pages).

The reports from 1972 contain descriptions of the research departments of the Institute. The Institute has eight air tunnels with continuous or shock operation which provide research facilities in the following ranges of parameters:

---- Mach number to 16
-----Reynolds number from $8 \cdot 10^4$ to $2 \cdot 10^7$
---- impact temperature, to 5000K
----velocity head to 3000 bars

The Institute also has a series of smaller research sections where there are several shock tubes, areas for research on plasma dynamics, the processes of combustion, and the interaction

of electron beams and solid body surfaces. The departments are well equipped with instruments and measuring devices, and some of them even have automatic data processing systems.

The following directions of research can be pointed out on the basis of the published reports:

---- physical kinetics, research on gas flows at high temperatures with physicochemical changes taken into account;

---- gas dynamics of combustion, the mechanics of the mixing of gas fuels and oxidizers in supersonic flows, the kinetics of the reaction at high temperatures;

---- the aerodynamics of high velocities, the experimental and theoretical analysis of supersonic and hypersonic flows, theoretical and experimental research on the flow stability of a viscuous gas;

----- methods of measurement in gas streams at a high temperature, methods of measuring the density, temperature, and velocity of gas, recording of processes that are rapidly taking place, automation of aerodynamic experiments.

Here are several characteristic works from the field of gas dynamics of combustion.

R.I. Solouchin (director of the Institute 1971-1976) presented research on the kinetics of chemical reactions in gas mixtures making use of shock waves. Measurement of the speed of recombination of molecules at temperatures above 3000 K was used as the basis for the simultaneous recording of the changes in the density and pressure of the rapid adibatic expansion of a dissociated gas. A "pocket" was inserted in the shock tube channel and , by "seizing" part of the shock wave flowing past, transformed it into a reflected wave. Afterwards occured rapid expansion and cooling of the gas in the "pocket". The change in the gas density was determined by using interferometric pictures. A helium-neon laser was used as a light source. The course of the changes in pressure was measured by using piezoelectric sensors. By comparing the curves of the changes in the temperature and density that were obtained using this

method it was possible to calculate the speed of recombination of gas molecules dissiciated in a reflected wave. For oxygen the rate of cooling using this method is 10^8 K s^{-1}, the rate of dissociation is (2.0-0.4) $\cdot 10^{14}$ cm^6 mol^{-2} s^{-1}, within a temperature range of 3000 to 3800 K.

W.K. Bajew, W. A. Jasakov, and others investigated combustion stability in a supersonic flow. A cone placed in the airstream served as a combustion stabilizer. Hydrogen was blown into openings made in the bottom of the cone, and it then burned in the toroidal vortex behind the cone. Under certain conditions it was determined that an increase in pressure appeared behind the cone, as compared with the static pressure in the stream.

At Mach 2.5 the ratio of these pressures was 1.8. This is an effect that surely can be used in the future in jet engines.

A.F. Datypow and P.W. Henkin analyzed the operation of a hypersonic jet engine during combustion in a supersonic flow. This is the first step in the undertaking that has as its goal the working out of a mathematical model of such an engine. The engine is divided into three components: diffuser, combustion chamber, and nozzle. The flow through each of the components is described by equations of the conservation of energy and mass while the incompleteness of the processes taking place is described by the coefficient of the loss of maximum work taken from concepts of exegetic analysis. On the basis of this a series of the characteristics of the engine in the range Mach 5 to 9 was drawn up.

The Institute has also carried out experimental research and theoretical analysis of the flow through hypersonic diffusers and nozzles having varying configurations.

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